Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Federal Department of Defence
Civil Protection and Sport DDPS

**armasuisse**
Science and Technology

# DEFTECH Update

February 2017

Dear Reader,

This document summarizes emerging technology signals related by Strategic Business Insights' (SBI) Scan and Explorer services that the Technology Foresight Research Program from armasuisse Science + Technology subscribes to.

For each trend, we try to anticipate what could be the implication for the armed forces. Each trend is also related to the original signal of change elaborated by SBI that the interested reader finds at the end of this document.

The intent is to stimulate strategic technology forward thinking in a form that is pleasant and quickly readable.

We hope you enjoy the journey!

Best regards,

Dr. Quentin Ladetto
Research Director – Technology Foresight

P.S. For any comment, suggestion or discussion: quentin.ladetto@armasuisse.ch

## Advanced Cryptography

Key research efforts in advanced cryptography are underway to progress technologies toward gaining secure abilities to maintain, search, and process fully encrypted confidential information using untrusted systems, especially for monetary transactions, voting, medical-records retrieval, and personalized medicine.

***Implication for Defense and Security****: Advanced-cryptographic methods for confidential information create both threats (through malicious use), and opportunities (through highly-secure systems) for defense and security.*

***Timing of Implication:*** ***now****/5 years/10 years/15 years*

***Capabilities:*** *Informations- & Daten-sicherheit (6.4), Nachrichten-Beschaffung (2.2), Information und Kommunikation (1.5)*

## Do-It-Yourself Human Augmentation

An increasingly wide range of technologies is making human-augmentation devices easier to develop. For example, a man created his own smart gun that only he can fire by implanting a radio-frequency-identification chip into his hand and an RFID reader into the handle of a gun.

***Implication for Defense and Security:*** *Human augmentation, using technologies such as exoskeletons and biological implants, is becoming a realistic prospect with many opportunities for the defense industry. However, as these technologies increase in capability and decrease in cost, individuals and groups may seek to develop human augmentation themselves, potentially creating threats to security.*

***Timing of Implication:*** *now/****5 years****/10 years/15 years*

***Capabilities:*** *Sanität (5.2), Individueller Schutz (6.1), Logistik (5.1)*

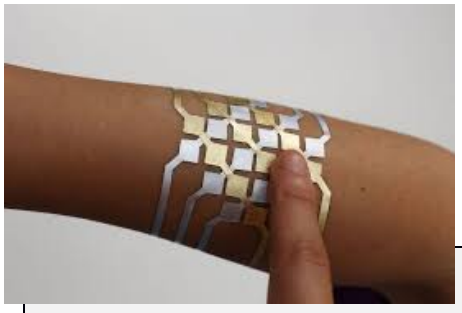
## Data Services in Vehicles

Robert Bosch and Mercedes-Benz are testing an in-vehicle system that uses ultrasound to scan the roadside for empty parking spots. The system sends the scan data to Bosch's cloud service, which then compares the data with digital maps and provides drivers with information about the locations of empty parking spaces.

***Implication for Defense and Security:*** *In military operations, the use of data communications and ultrasound technologies in military vehicles could aid in the detection of harmful objects and enemy combatants that are hidden from plain sight and in the communication of this information with friendly troops.*

***Timing of Implication:*** *now/**5 years**/**10 years**/15 years*

***Capabilities:*** *Logistik (5.1), Schutz von Waffen und Geräten (6.2)*



## Direct-Skin Wearables

Researchers from the Massachusetts Institute of Technology and Microsoft Research collaborated to create DuoSkin, a process that creates lightweight wearables similar to temporary tattoos. This technology can see use as a touch interface for digital devices, as a display that changes color according to the temperature of the wearer's skin, and as a device that uses near-field-communication technology to transmit data.

***Implication for Defense and Security:*** *Lightweight, direct-skin wearables may enable soldiers the access to technological equipment without the need to carry extra load. The ability to customize the functions of wearables to suit various operations (such as the health monitoring of soldiers and the transmission of data to the command center) could make wearables a flexible tool.*

***Timing of Implication:*** *now/5 years/**10 years**/15 years*

***Capabilities:*** *Information und Kommunikation(1.5), Führung von Untergbenen(1.2), Sanität (5.2)*

## Emotion-Recognition for Task Support

Researchers at the Fraunhofer Institute for Communication, Information Processing and Ergonomics are developing a diagnostic system that will enable machines to evaluate a person's state and determine whether the person is capable of performing a task or in need of assistance.

***Implication for Defense and Security:*** *Automated systems that can recognize emotions and predict capabilities could be integral to the development of task support software in the defense sector. For example, such systems may play a role in AR systems that help soldiers repair equipment.*

***Timing of Implication:*** *now/5 years/**10 years**/15 years*

***Capabilities:*** *Sanität (5.2), Führung von Untergbenen (1.2), Individueller Schutz(6.1)*

## Increasing Interest in Renewables

The world is in the midst of a dramatic shift toward the use of renewable energy, which has become more widely cost competitive with conventional energy despite declines in global fossil-fuel prices. Solar-photovoltaic (PV) costs have dropped by more than 80% in the past five years, which is driving record investments.

***Implication for Defense and Security:*** *Renewable-energy technologies are already a major focus of defense research. Decreasing costs of PVs may increase the pace of their adoption in defense and security applications. PV could reduce costs in military operations and provide a source of power to military systems in remote locations.*

***Timing of Implication:*** ***now****/5 years/10 years/15 years*

***Capabilities:*** *Logistik (5.1), Sicher-stellung der eigenen Mobilität(4.2)*

## Driverless Infrastructures

If driverless vehicles are to become successful, various infrastructures will also have to change. In particular, the vehicle-to-vehicle network capable of transmitting information about the vehicle's surroundings (such as road surfaces and obstacles) among multiple vehicles is an intriguing feature that could significantly enhance the capabilities of driverless vehicles.

***Implication for Defense and Security:***. *Autonomous-driving technology that can interconnect vehicles during military operations could improve the efficiency of transportation. Vehicle-to-vehicle networks may be necessary in combat zones in order for driverless vehicles to operate effectively.*

***Timing of Implication:*** *now/5 years/**10 years**/15 years*

***Capabilities:*** *Logistik (5.1)*

## Drone (In) security

The increasing use of drone technology is already causing problems, including the use of drones to smuggle contraband into prisons. Companies are developing ways to detect drones that fly into restricted airspaces.

***Implication for Defense and Security:*** *Security solutions that can protect sensitive airspaces from private drones are growing opportunities for defense organizations.*

***Timing of Implication:*** ***now**/5 years/10 years/15 years*

***Capabilities:*** *Schutz eigener Kräfte (6)*

## Long-Lasting Drugs

The Fold F(x) program by the US Defense Advanced Research Projects Agency found that "new synthetic polymers show promise for creating rugged, environmentally resilient medicines that don't lose potency over time." Taking such a pill may provide the same effect that swallowing several standard pills at multiple times throughout the day provide.

***Implication for Defense and Security:*** *Long-lasting, environmentally-resilient medication, could simplify drug treatments for soldiers. Medication that can remain in storage for long periods is highly desirable in military operations that may continue for months or years.*

***Timing of Implication:*** *now/5 years/**10 years**/15 years*

***Capabilities:*** *Sanität (5.2)*

## The Road to Fully Autonomous Robotic Pilots

The idea of an automatic pilot for aircraft has been a partial reality for quite some time; however, a robotic pilot fully capable of flying a commercial or military aircraft was a technological stretch until recently. KAIST is developing PIBOT2—a robot that can fly cargo planes and other existing aircraft and costs approximately $100,000 per unit.

***Implication for Defense and Security:*** *Unmanned vehicles are already common in defense and security but are expensive to build. Fully autonomous robotic pilots could fly existing planes, while reducing the risks to soldiers and civilians.*

***Timing of Implication:*** *now/**5 years**/10 years/15 years*

***Capabilities:*** *Logistik (5.1)*



## Wi-Fi: Beyond Communications

Wi-Fi technology can detect motion, track individuals, count people, and even recognize emotions. Manifold conceivable uses for Wi-Fi technology exist in application areas as diverse as security, safety, surveillance, market research, health care, and medicine.

***Implication for Defense and Security:*** *Wi-Fi-monitoring technology could enable soldiers in the field to determine a person's location, speed, and direction. This technology is undetectable because it emits no radio waves, enabling defense organizations to use it covertly. Wi-Fi technology could also aid search-and-rescue operations.*

***Timing of Implication:*** *now/**5 years**/10 years/15 years*

***Capabilities:*** *Information und Kommunikation(1.5), Nachrichten-Beschaffung (2.2)*

## X-Ray Reality

As augmented reality (AR) applications proliferate, people will begin to experience the benefits of AR's ability to overlay useful information onto real-world environments. The Rescue Assist mobile app from Mercedes-Benz uses AR to provide insight into where things like fuel lines, batteries, and other electrical components are located, helping to reduce the risk of further damage or injury that arises when a car needs to be unconventionally dismantled in order to save lives.

***Implication for Defense and Security:*** *In defense operations, AR may give soldiers easy access to information about equipment and their surroundings. For example, soldiers could use AR to see building schematics or information on how to fix a vehicle.*

***Timing of Implication:*** ***now**/5 years/10 years/15 years*

***Capabilities:*** *Information und Kommunikation(1.5), Nachrichten-Beschaffung (2.2)*

STRATEGIC BUSINESS INSIGHTS

EXPLORER

## Viewpoints

December 2016/January 2017

# Artificial Intelligence

By Michael Gold (mgold@sbi-i.com)

## *2016: The Year in Review*

The most publicized story about AI during 2016 may have been the victory of Google's AlphaGo software over a world champion go player; the method AlphaGo used (reinforcement learning) also started becoming part of training routines for robot arms and hands. Google's custom Tensor Processing Unit chips powered the AlphaGo victory, and Google revealed that the chips also find some use in delivering publicly available search and Street View services. The gross failure of a Microsoft chat bot that maintained a Twitter account embarrassed the software giant; but industry generally promoted and raised awareness about the possibilities of conversational computing. Cylance accumulated a billion-dollar valuation, with some analysts seeing the company as the world's first AI-start-up unicorn. Near the year's end, it appeared that large companies had announced record annual numbers of acquisitions of AI start-ups, and a record annual number of other AI start-ups announced receipt of venture investments. Other stories relevant to AI commercialization included progress toward use of advanced cryptographic technologies such as blockchains and smart contracts; introduction of English-language business bots in emulation of existing practices in China; and the initiation of important new AI competitions that challenge software to describe events in images and to apply commonsense reasoning about simple text questions. Paragraphs below detail some of these and other major stories about AI that occurred during 2016.

### *Conversational Computing*

Large companies promoted conversational computing during 2016, greatly raising awareness of the possibilities for chatting with and talking to computers. Facebook encouraged businesses to deploy chat bots in imitation of similar bots that have been available to users of WeChat and other popular messaging platforms in China during recent years. By the end of the third quarter of 2016, Amazon's Echo connected-audio device, which features the company's Alexa speech-recognition assistant, surpassed cumulative sales of 5 million units since the product became available during late 2014, according to a survey by Consumer Intelligence Research Partners. Analysts and product reviewers expected very brisk sales for Amazon's speech appliances during December 2016. Alexa gradually gained various new abilities to control third-party services during 2016, for example enabling users to arrange transportation using Uber by means of speech recognition rather than touch-screen interface. Google introduced a competing unit, Google Home. Google also updated its speech software, which it now calls Google Assistant, and which now operates as a chat bot in limited cases. Unconfirmed rumors suggested that Apple was developing a device to compete with Amazon Echo and Google Home. Also, Samsung acquired Viv Labs, a speech-assistant developer that was founded in part by the creators of Siri. Samsung indicated it plans to expand the use of speech technology in its fixed and mobile devices.

### *Acquisitions of AI Start-Ups by Brand-Name Companies*

During 2016, dozens of AI-related start-ups were acquired by major companies including Apple, Ericsson, Facebook, General Electric, Google, Ford, Intel, Microsoft, Salesforce, Samsung, and Twitter. Microsoft's acquisition of Genee stood in contrast to the company's long-standing in-house AI research and development practices. Salesforce acquired at least eight AI start-ups, opened an AI research lab, and applied its newly acquired AI talent to enhance customer-relationship management software, for example prioritizing lists of sales leads based on machine-learning models. Intel acquired a computer-vision specialist plus two companies that were developing AI chips. GE acquired at least two AI start-ups that will apparently play roles in the industrial giant's Predix predictive-maintenance machine-monitoring service. Perhaps surprisingly, to date GE has not claimed that any of its existing services make significant use of AI.

### *Deep Learning and Custom Chips for Language Translation*

Google deployed radically new translation software for public use. Unlike its predecessor, the software makes use of deep-learning software and graphics processor hardware to train recurrent neural networks. By

mid-November 2016, Google Translate was using the new software for the public to conduct translations among Chinese, English, French, German, Japanese, Korean, Portuguese, and Turkish languages. Significantly, the graphics processor units were efficient for training but not for actual translation duties. Also significantly, tests indicated that Google's custom Tensor Processing Unit chips performed translation more than three times as fast as conventional processors. Google did not reveal what a TPU chip is, but analysts suspect that it shares a certain attribute in common with graphics processors, namely the ability to apply an instruction (such as to multiply or add) to very many numbers at once (the chip likely implements a single-instruction, multiple-data architecture). Google indicated that TPUs are in use for public services including some searches and for the Street View navigation feature—but it did not indicate the extent of such use.

### *Moore's Law Repealed*

Google's custom chips for machine learning, including for AlphaGo, signal how stakeholders are requiring special-purpose circuitry to overcome a slowdown in industry's ability to miniaturize electronics. During August 2016, the Semiconductor Industry Association—a consortium that includes almost every semiconductor manufacturer in the world—published the 2015 edition of the International Technology Roadmap for Semiconductors. The reason for the delayed publication was not apparent, but members may have been holding out forlorn hope for a more optimistic itinerary. The forecast, which is important for coordination of semiconductor manufacturing equipment procurement and development, calls for a greatly reduced rate of progress in semiconductor miniaturization. Also, for some years, miniaturization has not accompanied commensurate efficiency gains, resulting in what Georgia Institute of Technology researchers call an "energy efficiency wall" (unlike in the past, a reduction of transistor size by 10% now yields energy savings of much less than 10%). Intel's acquisition of two AI hardware start-ups seems to reflect the computer-chip leader's acceptance that stakeholders will need various optimized chip designs that serve as application-constrained alternatives to general-purpose microprocessors. Another important sign that companies are reevaluating how we will approximate intelligence at the chip level emerged from Microsoft: By the end of 2016, the company claimed success for its Catapult project, resulting in the use of field-programmable gate arrays within all servers that deliver the company's public cloud-computing services. Microsoft cited machine-learning software tasks as being among the uses for the reconfigurable chips that are now on duty, for example for ranking search

results. Generally, chips that use alternative architectures cannot do all of the important tasks that microprocessors perform, but they can test the frontiers of high-performance, energy-efficient computation. They are likely to help improve diverse products and systems whose performance and capabilities are ultimately limited by batteries or practical power supplies.

### *The Rise of Reinforcement Learning*

The news of AlphaGo's victory inspired many articles and postings about risks of knowledge workers becoming unemployed. Yet AlphaGo's method of operation—reinforcement learning—appeared most prominently in research about robots, signaling that skilled and semiskilled manual laborers could be early casualties of the new machine age. During 2016, various organizations including Cornell University, Google, OpenAI, Stanford University, and University of California, Berkeley, reported use of reinforcement learning to demonstrate physical robots that learned to operate in gamelike simulations of virtual robots. Also, researchers from Princeton University and University of Münster published a minitreatise on how a larger family of methods that prominently includes reinforcement learning can solve many difficult design requirements for emerging smart grids—notably, requirements for reliability and continuity of electricity service in distributed-generation systems. Reinforcement learning saw very little commercialization activity, but Strategic Business Insights noted seven very small start-ups purporting to use reinforcement learning that were founded or received investments, or both, between late 2015 and late 2016.

### *AI Failures*

Microsoft was embarrassed by the poor public performance of its English-language Twitter chat bot, which has since been disabled. Pranksters easily trained the bot to express racist sentiments, forward propaganda messages, and otherwise offend people. The fiasco stood in contrast to Microsoft's successful Chinese-language bot, which had on the order of 40 million users according to reports in late 2015. With less drama but some dismay, users were disappointed in Facebook's new chat bots for business. Again, the situation stood in contrast with that of the business bots that were favored by Chinese-language users of social networks and messaging software. Facebook's algorithms also promoted fake news items (for example, fake reports that the Pope endorsed a candidate for US president) that were shared by millions of people. Earlier in the year, users chastised the company when human editors were seen as politically biased; Facebook's response was to introduce a trending-news bot, but the bot

transformed servers once again into propaganda channels. Company CEO Mark Zuckerberg found himself in the untenable position of explaining why he believes Facebook's pages have significant ability to influence purchases of advertiser's products but not votes. Remarkably, failures of AI software at Facebook and Microsoft revealed that expectations of AI are inflated, yet the failures apparently had no moderating effect on expectations of AI. Signs of benevolent superintelligence or a robot rebellion failed to materialize.

# *Look for These Developments in 2017*

Watch for indications that stakeholders are using AI in irresponsible ways, or that they are taking steps toward fostering professional responsibility. Partnership on Artificial Intelligence, an organization that was formed in September 2016 by Amazon, Facebook, Google, IBM, and Microsoft, intends to further the responsible use of AI and achieve other positive outcomes for AI; but the players declined to express how they intend to do so. Roughly at the same time, governments of Germany and California, and the magazine *Consumer Reports*, asked Tesla not to use the word *Autopilot* to describe its smart cruise control system, after a distracted driver died in a crash that occurred during July 2016. The Tesla vehicle failed to respond to a truck crossing the road. Reports indicated that the driver was at fault for the crash, but Tesla's software made it quite easy for drivers to ignore warnings for many miles while cars proceeded along freeways. A software update that Tesla issued during September 2016 imposes additional demands on driver attention. Significantly, results of test drives that *Car and Driver* published during February 2016 revealed that Tesla's Autopilot required far fewer human inputs on a 50-mile route near Ann Arbor, Michigan, than did comparable systems from BMW, Infiniti, and Mercedes. The results undoubtedly reflect high satisfaction with Tesla's smart cruise control. But the postcrash investigation reflected only an early step toward satisfying a still-unmet need for an "open and vigorous debate about what level of autonomy to grant computers" (as expressed by Allen Institute of Artificial Intelligence CEO Oren Etzioni in a 2014 essay).

### *Business Ecosystems for Speech Recognition*

Watch for the growth of new business ecosystems that revolve around the speech interfaces that Amazon, Google, and Samsung control. Amazon has succeeded with a business model that recruits diverse companies to

connect to and improve its Alexa speech assistant, for example to search merchandise catalogs and order local food and other services. But actually, Viv Labs and its founders had been promoting the same idea for some years. In an October 2016 announcement about its Viv Labs acquisition, Samsung endorsed the idea of third-party development and partnerships for a "broader service ecosystem." Also that month, Google announced that third parties would be able to integrate services with Google Assistant. Watch for expedited ways for businesses to integrate their own operations with new smartphones, appliances, and web services from Amazon, Google, and Samsung; and look to see if Apple deepens the ability of third parties to integrate with Siri. Also, watch to see what steps speech-platform owners take to deter potential security problems and pranks (use of speech to generate spurious e-commerce transactions, disable security alarms, or tamper with connected appliances, for example).

### *World Championships of AI*

New image-recognition competitions that were introduced in 2015 and 2016 are starting to demonstrate impressive results, so watch for possible related commercialization activity. Companies are likely to propose or deliver systems that supply captions for images, track moving objects in videos, draw precise outlines of objects within images, automatically apply different filters to the different objects in images, and generate 3D models of people and their body poses using 2D video as source material. Some of these technologies have potential for abuse: people modifying camera-captured images for pranks, fake news, and even blackmail.

Also watch for responses to another new form of competition, a Winograd Schema Challenge, which concluded its first public round during August with no victor. Computers were unable to understand text such as the following: "The trophy did not fit in the brown suitcase because it was too small." When asked to identify which item was too small—the trophy or the suitcase—AI software was hardly better than a pair of dice for providing correct answers. Transcripts from the annual Loebner Prize chat bot competition reveal that recent Turing tests have incorporated similar questions and generated similarly disappointing results. In a related development, software entries to the Allen AI Science Challenge, which concluded in February 2016, did not pass an eighth-grade multiple-choice science test, some of whose questions assume that students have common sense. Most leading AI labs have not been participating in contests that call for AI to have common sense. But such labs have strong reason to seek progress, whether by establishing competitions, demonstrating natural-language understanding at public events, or proposing new

technical approaches to endowing AI software with reasoning abilities comparable to those of young children. Many practical problems for machine translation and medical-assistant AI software could be solved by closing gaps in machine reasoning.

### *Overlap between AI and Advanced Cryptography*

Blockchains were the subject of much news and investigation but few important new implementations, so watch for stakeholders to deploy creative uses of the tamper-resistant shared ledgers that have potential to replace many accountants, bookkeepers, and bankers. The cybercurrency ether gained on the order of 1,000% in value during 2016, apparently on the strength of its ability to include smart contracts in its blockchain. The software-based contracts have further potential to replace human work including tasks currently carried out by contract attorneys, and to change the skill sets required for people in such jobs. Few if any signs of radical effects on white-collar employment emerged during 2016. But many banks began testing digital currencies and blockchains for interbank payment, including central banks in China, Singapore, and the United Kingdom. Also watch for increased research activity regarding other applications of advanced cryptography. Key efforts underway promise to show progress toward gaining secure abilities to maintain, search, and otherwise process fully encrypted confidential information using untrusted systems, especially for monetary transactions, voting, medical-records retrieval, studies in genomic and personalized medicine, and economics surveys.

January 2017

P1019

# Making Human Augmentation Easy

By Cassandra Harris (Send us feedback.)

**An increasingly wide range of technologies enable human augmentation.**

**Abstracts in this Pattern:**

SC-2016-12-07-022 on smart gun
SC-2016-12-07-005 on testing station
SC-2016-12-07-071 on stretchable polymer
SC-2016-12-07-072 on interscatter
SC-2016-12-07-066 on brain implant

By implanting a radio-frequency-identification (RFID) chip into his hand and an RFID reader into the handle of a gun, Amal Graafstra—a self-described "double RFID implantee" (http://amal.net )—recently created a do-it-yourself smart gun that only he can fire. Do-it-yourself augmentation may appeal to only a few brave individuals, but researchers are developing human-augmentation applications with broad appeal. Researchers from the Fraunhofer Institute for Manufacturing Engineering and Automation (Fraunhofer Society for the Advancement of Applied Research; Munich, Germany) have developed a biomechanical measuring station for testing the fit and functionality of prosthetic devices for athletes. The testing station could enable developers to optimize a variety of personalized wearable technologies quickly and precisely. New materials also will become important enablers of wearable technologies and augmentation applications. For example, researchers from the Massachusetts Institute of Technology (Cambridge, Massachusetts) and the Singapore University of Technology and Design (Singapore, Singapore) are developing stretchable-polymer structures that "remember" their original shape and can revert to that shape on exposure to a threshold temperature. The researchers aim to use the temperature of the human body as a trigger for the material's shape-memory response.

Human-augmentation applications that rely on implants often face roadblocks because enabling clear communications between power-limited devices within the human body and external devices can be challenging. But researchers from the University of Washington (Seattle, Washington) have developed *interscatter communication*—a method that enables devices such as electronic implants to communicate with smartphones "by converting Bluetooth signals into Wi-Fi transmissions." Implant technology is evolving rapidly. For example, University of Southern California (Los Angeles, California) neuroengineer Theodore Berger founded start-up Kernel (Los Angeles, California) to commercialize an implantable device that acts as an artificial hippocampus. Many scientists believe that the hippocampus "encodes experiences as long-term memories," so this device might be able to benefit stroke and head-trauma patients and people suffering from degenerative brain diseases. The implant might even enable people to store larger quantities of information within their brain.

**Signals of Change related to the topic:**

SoC871 — Augment and Advance
SoC852 — …Integration of Wearables
SoC828 — Augment Thyself

**Patterns related to the topic:**

P1007 — Medical Implants
P0968 — Fashionable High Tech
P0800 — Revisiting Cognitive Augmentation

STRATEGIC BUSINESS INSIGHTS

scan™

January 2017

P1012

# Traffic-Data Services

By Rob Edmonds (Send us feedback.)

**Data services for connected vehicles and transportation infrastructure are progressing.**

**Abstracts in this Pattern:**

SC-2016-12-07-087 on autobahn

SC-2016-12-07-068 on cars

SC-2016-12-07-100 on maps

Infrastructure providers, auto manufacturers, governments, and technology companies see significant potential in data services for connected vehicles and transportation infrastructure. Some services—for example, vehicle-to-infrastructure services—require significant cooperation among multiple stakeholders and systems. To help foster cooperation and facilitate systems testing, the German government launched the Digital Autobahn Test Field project. Developers are converting a stretch of autobahn between Munich and Nuremberg in Germany into a test platform for traffic-data services. Siemens (Berlin and Munich, Germany) and Infineon Technologies (Neubiberg, Germany) are among the commercial entities investing in the test platform. As part of the project, developers have created a smart bridge that features sensors capable of capturing and analyzing "data such as the strain, movements and inclinations of the bridge, as well as the temperature, humidity and pressure from vehicles." Developers hope that the data will enable experts to monitor the bridge's condition.

Some traffic-data services are specific to certain car brands. For example, Robert Bosch (Gerlingen, Germany) and Mercedes-Benz (Daimler; Stuttgart, Germany) are testing an in-vehicle system that uses ultrasound to scan the roadside for empty parking spots. The system sends the scan data to Bosch's cloud service, which then compares the data with digital maps and provides drivers with information about the locations of empty parking spaces. The sensors the system requires are already standard in Mercedes cars, and they can scan for parking spots while a vehicle moves as fast as 55 kilometers per hour.

Technological progress in traffic-data services will likely be the result of improvements in software services, sensors, and wireless communications. For example, software developers are beginning to reduce the substantial data requirements of some mapping systems. Start-up Civil Maps (Albany, California) is developing streamlined 3D-mapping technology that aims to position cars with an accuracy of 10 centimeters by converting the raw data from lidar sensors into a lightweight vector-based map. According to Civil Maps CEO Sravan Puttagunta, this conversion reduces "10 gigabytes of raw sensor data per kilometer down to 200 kilobytes per kilometer." Ford Motor Company (Dearborn, Michigan) is among Civil Maps' investors.

**Signals of Change related to the topic:**

SoC901 — Logistics and Infrastructure

SoC841 — …Urban Mobility

SoC809 — Industry 4.0

**Patterns related to the topic:**

P0981 — Automating Transportation

P0971 — Driverless Dynamics

P0912 — The Driverless Industry

January 2017

P1017

# Layering Capabilities

By Martin Schwirn (Send us feedback.)

**Researchers are using layering techniques and technologies to enable novel applications.**

**Abstracts in this Pattern:**

SC-2016-12-07-050 on DuoSkin
SC-2016-12-07-011 on imprint process
SC-2016-12-07-086 on printer

Researchers from the Massachusetts Institute of Technology (Cambridge, Massachusetts) and Microsoft Research (Microsoft; Redmond, Washington) collaborated to create DuoSkin—"a fabrication process that enables anyone to create customized functional devices that can be attached directly on their skin" (http://duoskin.media.mit.edu ). The researchers use a layer of gold leaf to create thin devices that resemble jewelry upon application to a person's skin. DuoSkin devices can see use as a touch interface for digital devices, as a display that changes color according to the temperature of the wearer's skin, or as a device that uses near-field-communication technology to transmit data.

Meanwhile, researchers from the Leibniz Institute for New Materials (Leibniz Association; Berlin, Germany) are using a new self-assembling gold-nanowire ink with an imprint process to create a flexible conductive grid that could find use in transparent electronics. To create the conductive grids, the researchers apply a layer of gold-nanowire ink to a substrate, and "a structured stamp is pressed on the substrate and forces the ink into a pattern…. The stamp is removed and the grid is treated in a plasma." Because this process requires much less gold than do processes that rely on ink that contains spherical particles of gold, it could enable the cost-effective manufacture of flexible displays, solar cells, and touch screens.

And Xerox Corporation (Norwalk, Connecticut) has developed the Direct to Object Inkjet Printer, which enables the precise application of ink to "smooth, rough, slightly curved or stepped surfaces at print resolutions ranging from 300 to 1,200" dots per inch. The machine's print heads contain tiny nozzles capable of applying layers of ink to both large objects such as football helmets and small objects such as bottle caps. Algorithms ensure the precision of the nozzles, and the ink the printer uses can stick to a wide variety of materials, including ceramics, glass, metals, and plastics. The Direct to Object Inkjet Printer could enable companies to customize and personalize a variety of 3D products quickly and easily.

**Signals of Change related to the topic:**

SoC646 — Flexible and Stretchable Electronics
SoC564 — Printing Body Parts
SoC443 — Print-Based Economy

**Patterns related to the topic:**

P0621 — Superresponsive Materials
P0564 — Beyond Silicon
P0092 — Interactive Materials

January 2017

P1015

# Systems Working with Emotions

By Cassandra Harris (Send us feedback.)

**Researchers are developing digital systems that work with human emotions.**

**Abstracts in this Pattern:**

SC-2016-12-07-031 on Emteq

SC-2016-12-07-014 on FKIE

SC-2016-12-07-067 on University of Aberdeen

Start-up Emteq (Brighton, England) has developed the Faceteq emotion-recognition system for virtual-reality (VR) headsets. Faceteq uses "small sensors embedded into a VR headset to measure electrical signals, heart rate, and muscle movement." These measurements enable the system to identify the wearer's emotional states and apply those emotions to the wearer's avatar in the virtual world. The company claims that Faceteq can detect a broader range of emotional states than can other technologies that use visual approaches alone. Systems that aim to use emotional factors as input reliably and accurately require information beyond biometric data. Researchers at the Fraunhofer Society for the Advancement of Applied Research's (Munich, Germany) Fraunhofer Institute for Communication, Information Processing and Ergonomics (FKIE; Wachtberg, Germany) are developing a diagnostic system that will enable machines to evaluate a person's state and determine whether the person is capable of performing a task or in need of assistance. FKIE researcher Jessica Schwarz developed a holistic model that provides a comprehensive look at human states and their causes. "In her model, she differentiates between six dimensions of user state that impact human performance: workload, motivation, situation awareness, attention, fatigue and the emotional state. She uses physiological and behavioral measures to detect these states." The model also takes into account external factors such as the task a person must perform, the time of day, and the environment in which the person must function. This model serves as the basis for the diagnostic system the researchers are developing, which uses several technologies to collect a broad array of physiological data.

Advanced emotion-recognition technologies could be integral to the development of automated systems capable of influencing people's emotions. For example, University of Aberdeen (Aberdeen, Scotland) professor Judith Masthoff is developing a computer algorithm that aims to give users emotional support by providing words of encouragement, praise, and reassurance. Although the algorithm is unable to identify a user's emotional state, perhaps it could eventually work in conjunction with emotion-recognition technologies. This combination of technologies could enable the development of applications such as virtual assistants that can identify a user's complex emotional states and provide feedback that meets the user's specific needs.

**Signals of Change related to the topic:**

SoC786 — Social Robots

SoC715 — Progress in Emotion Recognition

SoC483 — Beyond the Uncanny Valley

**Patterns related to the topic:**

P0846 — Emotions as a Feature

P0823 — Commercial Emotions

P0455 — Digital…Health-Care Services

Strategic Business Insights

scan™

January 2017

SoC919

# Advancing Renewable Energy

By Susan Leiby (Send us feedback.)

The world is in the midst of a dramatic shift toward the use of renewable energy, which has become more widely cost competitive with conventional energy despite declines in global fossil-fuel prices. According to REN21 (Renewable Energy Policy Network for the 21st Century; Paris, France), "The world now adds more renewable power capacity annually than it adds (net) capacity from all fossil fuels combined" (*Renewables 2016 Global Status Report*, REN21, June 2016; online). Solar-photovoltaic (PV) costs have dropped by more than 80% in the past five years, which is driving record investments—especially in developing countries. During a September 2016 round of bidding on a project to build a large utility-scale solar plant in Abu Dhabi, United Arab Emirates, a consortium of two companies bid $0.024 per kilowatt-hour, which is the latest in a series of record-low solar-PV bids. A new report from Deutsche Bank (Frankfurt, Germany) predicts a sharp decline in US solar-system costs that could spark a gold rush in US residential, commercial, and industrial solar markets in 2017 and beyond. Wind power is also playing a major role in new grid capacity, and wind power is a highly competitive option in a growing number of markets. The Global Wind Energy Council (Brussels, Belgium) sees wind power providing 20% of the world's electricity supply by 2030.

In October 2016, the United Nations (New York, New York) Paris Agreement reached the ratification threshold necessary for implementation. As the Paris Agreement goes into effect, it will spark new policies and various actions pertaining to reducing carbon emissions. Many countries recognize that energy decisions during the next 15 years may determine whether climate-change impacts in this century are manageable or potentially catastrophic, and increasing the generation of renewable energy is a low-carbon pathway free of the safety and security concerns inherent in increasing the generation of nuclear power, which is another low-carbon pathway. New carbon-trading systems and taxes are very likely to favor the development and commercialization of renewable technology. Because of policy support in key countries and substantial cost reductions, the International Energy Agency (IEA; Paris, France) increased its five-year growth forecast for renewables.

The transition to renewable-energy use is creating major disruptions within the energy industry and strategic challenges for traditional-energy producers. For example, Germany's traditional utility power generators fought the rise of subsidized renewables and are now experiencing dramatically declining profit margins as a result of lower energy demand, excess capacity, and merit-order requirements to buy renewable energy first. Indeed, electricity prices in Germany went negative for several hours in May 2016 after the nation's renewable-energy generation reached an all-time high. The outlook for Germany's utility sector remains very uncertain and could worsen if renewable-energy and energy-storage costs continue to decline, attracting customers away from utility companies.

*The transition to renewable-energy use is creating major disruptions.*

Implementing renewable technologies can have negative consequences, including unfavorable aesthetic impacts on the landscape. In 2012, Denmark's government agreed to construct a number of wind turbines along the coast of Denmark; however, the government recently cancelled the turbines' construction, deeming the turbines too expensive and too ugly. Although the government plans to replace the proposed coastal wind turbines with a new offshore wind farm in 2025, the cancellation of the coastal wind

turbines does create uncertainty in Europe's renewable-energy industry. Nonetheless, offshore-wind capacity is set to see significant growth worldwide. Wind technology is well proven in Northern Europe, and the wind industry is working to develop innovative turbine designs and infrastructure improvements to reduce high costs. In addition, developers have completed the first commercial offshore wind farm in North America, which brings the United States to the cusp of tapping its massive offshore-wind-energy potential.

Renewable-energy applications are expanding into nontraditional sectors of the economy. For example, in France, researchers from civil-engineering firm Colas Group (Boulogne-Billancourt, France) and the French National Institute for Solar Energy (Le Bourget-du-Lac, France) collaborated to develop photovoltaic panels for direct application to existing pavements. The panels are easy to install and have a life expectancy of 10 to 20 years. Colas expects to begin installing the panels on private driveways and roads within a few years. Direct renewable-power contributions to the transportation sector are increasing through the charging of electric vehicles (EVs). EVs are becoming increasingly viable competitors to conventional vehicles because the cost of batteries is approaching $150 per kilowatt-hour—a milestone that might occur by 2020. Solar PV could also work in harmony with other electrification technologies to reduce the transportation sector's carbon footprint. SunPower Corporation (San Jose, California) recently signed a power-purchase agreement to supply the metro system in Santiago, Chile, with PV-generated electricity.

An increasingly common practice is to develop utility-scale renewable-energy projects on contaminated *brownfields*—sites that have seen use for industrial purposes. Such projects offset the cost of brownfield cleanup and create new business opportunities from disused but often well-sited land. For example, the Ukrainian government is in talks with two US investment groups and four Canadian energy companies about creating a 1-gigawatt solar plant in the exclusion zone surrounding the site of the Chernobyl nuclear-plant accident. The site has existing electricity infrastructure for power transmission, and acquiring and developing the land would be inexpensive. In addition, developing and using the site would cause minimal disruption because the land has been unoccupied since the evacuation that followed the nuclear accident. Similarly, Australia has about 50,000 abandoned mine sites that could host solar farms to help meet the country's growing demand for renewable energy.

Renewable energy still accounts for a small share of worldwide electricity production—only 23.7% at the end of 2015, according to REN21's *Renewables 2016 Global Status Report*. Fossil-fuel-based power generation will continue to dominate power generation for some time, but the transition to renewables-based generation is gaining speed. For example, the low cost of natural gas, availability of wind and solar energy, technological advances, and regulatory developments are causing the United States to use less coal-fired energy. And a new report by the Canadian government's Policy Horizons Canada (Ottawa, Canada) energy think tank forecasts that fossil fuels will wane in importance more quickly than people once thought they would and that this waning will affect Canada's newfound status as an energy superpower.

**SoC919**

**Signals of Change related to the topic:**
SoC848 — Fossil-Fuel Headwinds
SoC799 — Renewable Considerations
SoC746 — …Power of Solar Energy

**Patterns related to the topic:**
P0983 — Tackling Fossil Energy…
P0969 — The Age of Solar Energy
P0959 — …Renewable-Energy Use

December 2016

SoC912

# Considering Driverless Infrastructures

By Martin Schwirn (Send us feedback.)

For more than five years, the prospect of driverless cars' seeing widespread adoption within a decade or two has caught the attention of industry participants, analysts, the media, and consumers in general. In 2010, Google (Alphabet; Mountain View, California) received a great deal of media attention when it revealed that it had been testing its fleet of autonomous vehicles on public streets in the United States, including on busy highways during rush hour and on challenging urban and rural roads. Google's foray into the realm of driverless vehicles created a chain reaction in the automotive industry, which is now forming a new understanding of what automobiles could be in the future. Car technology will change, but if driverless vehicles become successful, various infrastructures—including those in urban environments and those in use to capture and provide information—will also have to change.

*Some projects that do not directly focus on driverless applications still offer insights about how information could see use more efficiently in urban environments.*

A June 2016 *Automobile* article by two automotive-industry veterans—Christopher Borroni-Bird, Qualcomm's (San Diego, California) vice president of strategic development and former director of General Motors' (GM; Detroit, Michigan) Advanced Technology Vehicle Concepts and Electric Networked Vehicle (EN-V) Program, and Lawrence Burns, GM's former vice president of research and development—discusses how urban mobility might change with the advent of driverless cars. In the article, the authors provide a vision of swarms of electric driverless pods in urban environments that address urban transportation requirements more efficiently than do privately owned cars and taxis, which carmakers did not design specifically to meet mobility needs in city centers. The authors even envision a time when cities might ban cars from city centers. They also argue that the changing mobility landscape could drastically alter business models in the automotive industry, explaining that "the opportunity exists to profit significantly from selling miles, trips, and experiences instead of cars" ("Urban Mobility: Rethinking the Future of Transportation," *Automobile*, 27 June 2016; online). Such drastic changes also point to the need for a rethinking of urban planning and design. In fact, experts disagree about whether driverless cars will lead to greater population density in cities or to suburban sprawl, as SoC905 — Planning for Future Urban Environments outlines. A study by the Massachusetts Institute of Technology (Cambridge, Massachusetts) indicates that self-driving cars could eliminate the need for 80% of cars. And a McKinsey & Company (New York, New York) report estimates that autonomous cars could reduce the space necessary for parking by 25% by 2050, cutting traffic and freeing up a tremendous amount of space for other uses. In contrast, Robert McDonald, lead scientist for the Nature Conservancy's (Arlington, Virginia) Global Cities Program, argues that cities increase in size and become more sprawling as people gain the ability to move more quickly.

In particular, a need will emerge to establish data infrastructures that enable cities to make full use of their existing network of streets and parking lots. Researchers at the National Autonomous University of Mexico (Mexico City, Mexico) ran computer simulations that suggest the use of autonomous vehicles would improve traffic-flow efficiency only by 7% and only in severe traffic. However, the researchers also found that the use of autonomous vehicles

in combination with smart traffic lights could improve traffic-flow efficiency by 200%. The way the smart traffic lights function in the simulation is relatively simple: The lights monitor the waiting traffic in each direction and give priority to the streets with the most traffic. This setup requires no communication between the smart traffic lights and the autonomous vehicles (beyond the vehicles' detecting whether the lights are red or green). Some projects that do not directly focus on driverless applications still offer insights about how information could see use more efficiently in urban environments. For instance, in select cities, high-end Audi (Volkswagen Group; Wolfsburg, Germany) vehicles will be capable of using a new vehicle-to-infrastructure (V2I) service to communicate with traffic lights and inform Audi occupants when a light is set to change from red to green. Audi plans to expand its V2I service into additional cities and "envisions a world where this sort of communication is built into the navigation system, which, when combined with auto stop-start technology, could reduce commutes and increase efficiency" ("Your next Audi might be talking to traffic lights," Roadshow, 15 August 2016; online). Other companies are looking at the benefits of sharing information among vehicles. Robert Bosch (Gerlingen, Germany) and Mercedes-Benz (Daimler; Stuttgart, Germany) are running a pilot program in Stuttgart, Germany, to investigate an in-vehicle system that uses ultrasound to scan the roadside for empty parking spots. The system sends the scan data to Bosch's cloud service, which then compares the data with digital maps and provides drivers with information about the locations of empty parking spaces. The sensors the system requires are already standard in Mercedes cars, and they can scan for parking spots while a vehicle moves as fast as 55 kilometers per hour. If this community-based-parking service is successful during the pilot program, it could become a common feature in navigation systems. Such information crowdsourcing could play an important role in driverless applications that aim to advance traffic management, and the use of crowdsourced information could help driverless cars improve their operations. For instance, Jaguar Land Rover (Tata Motors; Mumbai, India) is working on autonomous off-road applications that use technology to identify the type of surface the vehicle is on and to sense a path in off-road environments, which lack the structure of roads. The concept cars use ultrasonic sensors and stereo cameras that scan the path ahead of and below the vehicle to identify the type of surface the vehicle is on and to locate bumps, holes, and other obstacles. The company has demonstrated a short-range communications technology that enables multiple cars within proximity of one another to form a connected convoy. The vehicles in such connected convoys can share information, and Jaguar Land Rover head of research Tony Harper highlights that "in the future, a convoy of autonomous vehicles would use this information to automatically adjust their settings or even change their route to help them tackle the obstacle" ("Jaguar Land Rover Demonstrates All-Terrain Self-Driving Technology," Jaguar Land Rover, 11 July 2016; online). Self-driving technologies for use in standard street vehicles mostly face challenges that relate to navigating traffic, but self-driving technologies for use in off-road vehicles face a completely different set of challenges. Any advances in self-driving capabilities for off-road vehicles will also benefit the self-driving capabilities of street vehicles. For example, technology capable of sensing holes and bumps in off-road driving could see use to sense potholes and speed bumps in street driving. In particular, the vehicle-to-vehicle network capable of transmitting information about road surfaces among multiple vehicles is an intriguing feature that could significantly enhance the capabilities of driverless vehicles.

## SoC912

**Signals of Change related to the topic:**
SoC866 — A Flock…a Shoal of Drones
SoC841 — …Cars in Urban Mobility
SoC840 — Roaming Robots

**Patterns related to the topic:**
P0981 — Automating Transportation
P0921 — Traffic Experiments
P0900 — Driverless Cars' Ripple Effects

December 2016

P0998

# Drones on Top of the Hype Cycle

By Martin Schwirn (Send us feedback.)

**The potential applications of unmanned aerial vehicles seem limitless; concerns about market hype exist.**

**Abstracts in this Pattern:**

SC-2016-11-02-012 on videoconferencing
SC-2016-11-02-080 on flying taxis
SC-2016-11-02-063 on hotel pods
SC-2016-11-02-042 on crime
SC-2016-11-02-087 on drone detection

The preserve of military agencies only a few years ago, unmanned-aerial-vehicle (UAV) technology is now finding use in even the most frivolous consumer applications. Investors, companies, and consumers will have to calibrate their market expectations, because reality is unlikely to live up to the current hype. Google (Alphabet; Mountain View, California) recently secured a patent for a mobile videoconferencing system that relies on a small drone. The patent depicts a quadcopter that uses a mounted rectangular display for telepresence applications. Factors such as questionable stability, propeller noise, and the short battery life common among drones seem to jeopardize the practicality of the system. Airbus Group (Blagnac, France) has launched multiple projects in an effort to commercialize autonomous commuter aircraft within a decade. Although the emergence of commercial transportation services that rely on autonomous flying taxis would provide wide-ranging benefits for mobility and urban environments, developing commercially practical autonomous commuter aircraft is a tremendously ambitious goal. In contrast, architecture firm HOK (St. Louis, Missouri) has developed the highly conceptual Driftscape scheme. Driftscape uses "a fleet of drones that would serve as a portable hotel…. The scheme calls for using drone technology to create mobile pods that can be flown around the world and placed in areas not typically conducive to building a hotel." The Driftscape concept won the grand prize in the 2016 Radical Innovation Award (http://radicalinnovationaward.com ) competition.

Despite their questionable feasibility and practicality, many proposed drone applications have the potential to deliver a variety of benefits; however, the increasing use of existing drone technology is already causing problems. In the United Kingdom, "reports made to police concerning the illegal use of commercially available remote-controlled aircraft surged by 352 percent between 2014 and 2015." Allegedly, people have used drones to smuggle contraband into correctional institutions and to watch people enter their PINs at ATMs. Perhaps not surprisingly, companies are developing ways to detect drones that fly into restricted airspaces. For example, drone-detection-technology developer Dedrone (San Francisco, California) is partnering with Airbus's electronics division "to bring drone detection to wide open spaces and remote locations."

**Signals of Change related to the topic:**

SoC866 — A Flock…of Drones
SoC796 — Drone Update
SoC677 — The Sky's the Limit…

**Patterns related to the topic:**

P0911 — Drones' Capabilities Expand
P0871 — Drone Infrastructures
P0809 — Serious Drones

December 2016

P1000

# Revenue Headwinds for Drugmakers

By Martin Schwirn (Send us feedback.)

**New contracts, medication types, and manufacturing technologies might reduce pharmaceutical companies' revenue potential.**

**Abstracts in this Pattern:**

SC-2016-11-02-011 on value-based contracts
SC-2016-11-02-019 on perishability
SC-2016-11-02-070 on 3D-printed capsules
SC-2016-11-02-066 on 3D-printed device

In May 2016, health-insurance company Cigna (Bloomfield, Connecticut) announced that it had established value-based contracts with three pharmaceutical companies that manufacture a new class of cholesterol drugs. The contracts require the companies to offer price discounts if their cholesterol medications fail to reduce patients' low-density-lipoprotein (LDL) cholesterol as significantly as they did during clinical trials. Cigna and several other companies have been negotiating such value-based contracts with pharmaceutical companies since 2014 and have reached agreements about several expensive drugs in use to treat diseases such as cancer and hepatitis C. In another development, the Fold F(x) program by the US Department of Defense's (Arlington County, Virginia) Defense Advanced Research Projects Agency (DARPA; Arlington, Virginia) found that "new synthetic polymers show promise for creating rugged, environmentally resilient medicines that don't lose potency over time." The development of such long-lasting medication would reduce the need for frequent purchases of replacement medication.

Advances in 3D printing can also affect pharmaceutical companies' revenue. Multiply Labs (San Francisco, California), backed by Y Combinator (Mountain View, California), claims that it has developed time-release capsules for vitamins and supplements. The capsules "are printed with a patent-pending pharmaceutical polymer, to control the release of the nutrients at certain intervals throughout the day." Taking such a pill may provide the same effect that swallowing several standard pills at multiple times throughout the day provides. Even consumers might be able to use 3D-printing technology to reduce medication costs. A commenter on the social-news website Reddit (Advance Publications; New York, New York) recently announced that he is developing open-source design files that anyone can use to 3D print a device that replicates the functions of the EpiPen (Mylan; Canonsburg, Pennsylvania) epinephrine auto-injector, which delivers a lifesaving dose of adrenaline to users who are suffering from severe allergic reactions. Mylan has increased the cost of the EpiPen multiple times since 2007, when it acquired the rights to sell the product. In 2009, the cost of a pair of EpiPens in the United States was about $100; following the most recent price increase, the cost of a pair is about $600.

**Signals of Change related to the topic:**

SoC863 — The Right Dose
SoC806 — Developments in Drug Delivery
SoC770 — Implantable Health-Care Devices

**Patterns related to the topic:**

P0958 — Changing Pharmaceuticals
P0815 — …Medical Diagnostic Tests
P0611 — Medication in Transition

December 2016

P1006

# Robots and Employment Markets

By Peter Batty and Martin Schwirn (Send us feedback.)

**Advanced robots are moving into job sectors and geographical regions that many people thought were immune to automation.**

**Abstracts in this Pattern:**

SC-2016-11-02-045 on taxes
SC-2016-11-02-013 on manufacturing
SC-2016-11-02-021 on service jobs
SC-2016-11-02-088 on piloting

Robots and robotic applications are gaining the ability to perform an increasing number of tasks. If automation technologies find widespread use, new considerations will emerge. Deutsche Post (Bonn, Germany) CEO Frank Appel recently suggested taxing the work that robots do. Chancellor of Austria Christian Kern also proposed the idea of a machine or robot tax, pointing out that such tax schemes may be necessary to finance social systems in a world where fewer people are working because machines have taken their place.

Robots already affect work that employs high numbers of people. Asia was once home to plentiful, low-cost labor, but rising standards of living have pushed wages up. Western firms such as Adidas (Herzogenaurach, Germany) are moving some production operations from Asia to their home countries; however, instead of hiring local workers, they are implementing automation technologies. For example, the new Adidas factory in Ansbach, Germany, uses custom automation technologies and robots to produce 500,000 pairs of shoes annually. This factory produces only a small fraction of the company's total worldwide output, but Adidas is only one of several companies that are using automation technologies to manufacture in developed countries. Robots may also replace human workers in service jobs in developed countries. Wal-Mart Stores (Bentonville, Arkansas) is currently testing the Dash—a robotic shopping cart from Five Elements Robotics (Wall Township, New Jersey). The cart, which can guide shoppers to the products they are looking for and bring the items a shopper purchased to his or her car in the parking lot, could replace many low-wage service workers.

Some recent developments illustrate the potential for robotic systems to see use in virtually every field. The idea of an automatic pilot for aircraft has been a partial reality for quite some time; however, a fully functional robotic pilot capable of flying a commercial or military aircraft was a technological stretch until recently. KAIST (formerly the Korea Advanced Institute of Science and Technology; Daejeon, South Korea) is developing PIBOT2—a robot that can fly cargo planes and other existing aircraft and costs approximately $100,000 per unit.

**Signals of Change related to the topic:**

SoC884 — Rights for Robots
SoC877 — Automation…
SoC840 — Roaming Robots

**Patterns related to the topic:**

P0935 — Humanoids, Stand Up!
P0767 — Drones' Driving Service Robotics
P0597 — Robotic Helpers across Industries

STRATEGIC BUSINESS INSIGHTS

scan™

December 2016

SoC911

# Wi-Fi: Beyond Communications

By Martin Schwirn (Send us feedback.)

Most consumers know Wi-Fi technology, which has become almost ubiquitous in developed countries, as a communications technology that transmits data and connects devices; however, Wi-Fi technology can also see use to detect motion, track individuals, count people, and even recognize emotions. Manifold conceivable uses for Wi-Fi technology exist in application areas as diverse as security, safety, surveillance, market research, health care, and medicine. But advancing research in the use of Wi-Fi technology for surveillance and tracking applications also raises the specter of surreptitious monitoring and privacy invasion, and such applications have their own security issues. Nonetheless, interest in the development of such applications has been on the rise for the past five years.

- In 2012, researchers at University College London (London, England) developed a suitcase-size device capable of detecting people through walls by tracking frequency changes in Wi-Fi signals from home routers (the frequency of a radio wave changes when it reflects off a moving object). The researchers were able to use the device to determine a person's location, speed, and direction, and the device is undetectable because it emits no radio waves.
- In 2013, Massachusetts Institute of Technology (MIT; Cambridge, Massachusetts) professor Dina Katabi and graduate student Fadel Adib published a paper that describes Wi-Vi—a system that uses Wi-Fi technology to locate people in rooms from the outside. The system transmits low-power Wi-Fi signals and uses the reflections of those signals to identify people behind walls and closed doors.
- In 2014, MIT Computer Science and Artificial Intelligence Laboratory (CSAIL) researchers Fadel Adib, Zachary Kabelac, and Dina Katabi published a technical report that outlines a technique for using Wi-Fi signals to monitor motion precisely enough to detect—across a room or even through walls—the subtle movements of a person's chest as the person breathes. By measuring changes in the reflection time of the Wi-Fi's low-power radio signals, the researchers precisely tracked the large and small movements of multiple people simultaneously. At the time, the researchers were exploring potential applications in areas such as health self-monitoring and search-and-rescue operations.
- In 2015, researchers at the University of California, Santa Barbara (Santa Barbara, California), discovered a way to analyze fluctuations in the signal strength between two Wi-Fi cards to calculate fairly accurately the number of people in the area between the cards. The researchers placed Wi-Fi cards on opposing sides of a 70-square-meter area, and had as many as nine people move around in that area. A person's crossing the direct line of sight between the two cards weakens the signal, and people who are in the area but not in the direct line of sight between the two cards scatter the signal. The researchers created a probabilistic mathematical framework for use in analyzing these signal fluctuations to determine the number of people in the area.

*Advancing research in the use of Wi-Fi technology raises the specter of surreptitious monitoring.*

During the past year, researchers and companies have expanded the uses for such systems and approaches, which points to an increase in the number of application areas for Wi-Fi technologies and their growing potential to see use in commercial applications.

In October 2015, CSAIL researchers—including Fadel Adib and Dina Katabi—published a paper that presents RF-Capture—a device that uses Wi-Fi signals to look through walls. A wireless transmitter in the device emits radio signals, and a receiver captures the reflected signals. An algorithm interprets the information in the reflected signals to determine the silhouette of a body on the other side of a wall. The algorithm can even distinguish among as many as 15 people with 90% accuracy and track people's motion and posture. The images that RF-Capture creates resemble the heat signatures that thermal cameras display. Since 2015, Dina Katabi and colleagues have launched start-up company Emerald (www.emeraldforhome.com ) to commercialize their innovations in Wi-Fi technology. The company is developing a system that monitors the movements of senior citizens at home and identifies the movement patterns of a falling person. Emerald's technology uses the radio signals that reflect off a person's body to track a person's movement and therefore does not require senior citizens to wear devices, which they might forget or wish not to carry at all times.

For a number of years, Cognitive Systems Corp. (Waterloo, Canada) has been working on a chip capable of picking up and analyzing the wireless radio signals that electronic devices emit. Recently, the company started developing the Aura home-monitoring system, which comprises "a hub and one or more sensors plugged into electrical outlets that monitor motion by detecting ripples in wireless signals" (https://cognitivesystems.com ). A mobile app will use the system's analysis to notify homeowners if any unusual activities occur in their home.

Recently, CSAIL researchers Dina Katabi, Fadel Adib, and Mingmin Zhao presented a system that indicates the extent of wireless technology's potential identification and information-capturing capabilities. In September 2016, the researchers announced that they had developed a way to use wireless signals to recognize emotions. The researchers' EQ-Radio device emits signals that the human body reflects back for analysis. The device measures changes in a person's heart rhythm and breathing and then categorizes the person as angry, excited, happy, or sad on the basis of these measurements. Dr. Katabi believes that EQ-Radio could find use in application areas as diverse as health care, entertainment, and market research. For example, marketing companies could use EQ-Radio to measure people's reactions to advertising content in real time, and smart-home systems could use data from the device to adjust the temperature of a room on the basis of a user's mood. Dr. Katabi intends to make use of such emotion-detection technology in applications that Emerald will develop in the future.

The use of Wi-Fi technology to ensure the safety of elderly people who live on their own, to monitor home environments while homeowners are not at home, and to enable law enforcement to gain situational awareness offers unequivocal benefits. But such technology could also see use to spy on people, to extract emotional feedback from consumers for sales purposes, and possibly even to obtain medical information that might affect a person's ability to secure insurance coverage, for example. Although such technology promises to provide security benefits, it may also jeopardize security when in use for nefarious purposes. For example, criminals could use Wi-Fi technology that looks through walls to see if anyone is in a home they wish to rob. No doubt, research will continue and uncover even more potential applications for Wi-Fi technology. Whether such applications will find a commercial market remains uncertain, and the accuracy and reliability of commercial systems are currently untested.

## SoC911

**Signals of Change related to the topic:**
SoC902 — …Atypical Spying
SoC797 — Internet of (Growing) Threats
SoC741 — …End of Anonymity

**Patterns related to the topic:**
P0850 — Cybersecurity's…Conundrum
P0792 — Eavesdropping by Proxy
P0708 — Indirect Eavesdropping

STRATEGIC BUSINESS INSIGHTS

scan™

December 2016

SoC909

# Augmented Reality Provides X-Ray Vision

By Martin Schwirn (Send us feedback.)

As augmented-reality (AR) applications proliferate, an increasing number of mobile-device users will encounter a new world in which digital elements mix with real-world settings and environments. AR applications and their benefits are manifold. P0986 — *Pokémon Go:* Game and Business Model discusses Niantic's (San Francisco, California) AR mobile game *Pokémon Go* (www.pokemongo.com ), which became an instant success. The game not only entertains players but also provides businesses with opportunities to attract clients and customers. Serious AR applications that perform useful functions also exist. For example, AR applications can enable users to see through smoke, to see the systems and components behind surfaces and inside objects, to perform dangerous work more efficiently and safely, and to design various processes more effectively. Product use by consumers, industrial applications, medical procedures, and emergency and rescue work can all benefit from AR applications that give users access to information that is hidden from plain sight.

*Product use by consumers, industrial applications, medical procedures, and emergency and rescue work can all benefit from AR applications that give users access to information that is hidden from plain sight.*

In October 2015, P0834 — Transparent Views presented multiple AR applications that enable medical personnel to look inside a patient's body, so to speak. For example, Evena Medical's (Roseville, California) Eyes-On Glasses medical smart glasses can generate a vein road map to help medical professionals administer injections and catheters. The device emits multiple beams of near-infrared light that veins absorb and tissue reflects, and the device's cameras track the locations of absorption and reflection. A processor in the device then uses those data to create a map of a patient's veins, which a projector displays on the device's transparent display. And Samuel Achilefu and his colleagues from the Washington University School of Medicine (Washington University in St. Louis; St. Louis, Missouri) are developing fluorescent goggles that enable doctors to identify cancer cells that remain in a patient after tumor removal. Doctors inject a patient with a fluorescent dye that binds to cancer cells and glows under near-infrared light. A camera on the goggles identifies fluorescing cancer cells, and a computer then overlays their locations onto the doctor's field of view. These applications present information in a way that is easily processable by humans, enabling doctors and nurses to administer treatments and conduct procedures very intuitively.

As AR applications proliferate, consumers will begin to experience the benefits of AR's ability to overlay useful information onto real-world environments. For example, Hyundai Motor Company (Seoul, South Korea) developed a mobile app that provides users with an AR manual for certain Hyundai vehicle models. The app offers information about vehicle maintenance and repair, and car owners can also use the app to familiarize themselves with the features of their vehicle. For example, viewing a vehicle's dashboard through the screen of a mobile device causes the app to display digital labels over the various buttons, dials, and levers on the dashboard. Touching a digital label on the device screen makes the app display additional information about the item to which the digital label applies. And viewing the

vehicle's engine through a mobile device and touching, for example, the digital label for the air filter triggers animated step-by-step instructions for cleaning or changing the filter. (*Gizmag* provides video examples of the app's use at www.youtube.com/watch?v=8iVSCpk0xOw ). In the future, AR applications could change the way consumers make purchase decisions. For instance, the Lowe's Innovation Labs (www.lowesinnovationlabs.com ) division of home-improvement chain Lowe's Companies (Morrisville, North Carolina) is developing Lowe's Vision—an AR app that uses Google's (Alphabet; Mountain View, California) Tango AR platform to enable users to view virtual appliances, flooring, furniture, and various home improvements in their home environment through the screen of a mobile device. Lowe's intends for this AR visualization tool to facilitate consumers' purchase decisions.

Not surprisingly, AR offers a wide range of opportunities to improve industrial operations. Glasses that overlay information onto real-word environments can provide myriad benefits in industrial settings. In 2014, Deutsche Post DHL (Bonn, Germany) ran a pilot project at a distribution center in the Netherlands to test smart glasses running augmented-reality software. The glasses projected process steps within the employees' visual field, overlaying instructional information on the physical environments in which the employees were operating. During the pilot, efficiency increased by 25%. Volkswagen (Volkswagen Group; Wolfsburg, Germany) considered using a similar technology for its operations. Experts also envision the use of such AR applications on construction sites to aid in complicated assembly work.

AR technology may have the most immediate impact in emergency situations, providing first responders with a wealth of beneficial information. The Rescue Assist mobile app from Mercedes-Benz (Daimler; Stuttgart, Germany) gives emergency personnel highly detailed information about Mercedes vehicles when they use a mobile device to scan the QR codes the company puts on its vehicles. The company recently updated the app to include AR features. When emergency personnel view a vehicle through the screen of a mobile device, the app shows them digital overlays of "color-coded representations of internal components, including key areas to be wary of when doing things like cutting through vehicles to free trapped passengers. The app will provide insight into where things like fuel lines, batteries and other electrical components are located, in order to help reduce the risk of further damage or injury that arises when a car needs to be unconventionally dismantled in order to save lives" ("AR in Mercedes-Benz's Rescue Assist app gives first responders an inside look," TechCrunch, 27 July 2016; online). AR applications can also combine with advanced imaging technologies to provide emergency personnel with valuable visual information in disaster areas where various conditions limit visibility. For example, École Polytechnique Fédérale de Lausanne (Lausanne, Switzerland) researchers have created a hands-free thermal-imaging system for firefighters. The system comprises a helmet-mounted thermal camera and a pair of AR glasses that overlays thermal images from the camera onto the wearer's field of vision. The system enables firefighters to see people and potential hazards through smoke and darkness without having to carry and operate a standard thermal camera, which is typically bulky and heavy.

Gaming and entertainment applications of AR technology have captured the imagination of the media and consumers; however, more useful applications of AR technology have the potential to increase efficacy and efficiency in a variety of operations in a wide range of industries. Indeed, opportunities to make use of constantly improving AR technology exist in essentially every industry.

## SoC909

**Signals of Change related to the topic:**
SoC810 — …Real-World Holodeck
SoC803 — Entertaining Augmented Reality
SoC267 — Mixed Reality's Tipping Point

**Patterns related to the topic:**
P0986 — *Pokémon Go*…
P0877 — Retail in Hybrid Realities
P0834 — Transparent Views